

What is claimed is:

Part B1

1. An imaging system for invasive therapy of a patient, the system comprising:
an imaging apparatus that can provide a cross-sectional image of a patient;
a medical instrument comprising a fiducial object that can be imaged in the same image as a targeted site of the patient.

2. The system of claim 1 wherein the fiducial object representation in the image is unique for the pose of the instrument within the therapeutic field or range of motion of the instrument.

3. The system of claim 1 or 2 wherein the image can produce three identifiable points to coordinate pose of the instrument and the targeted site of the patient.

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4. *as* The system of any one of claims 1 through 3 wherein the instrument pose is directly manipulated in reference to the medical image.

5. The system of any one of claims 1 through 4 wherein the relative position and orientation of the medical instrument and target site of the patient can be determined from the information contained in a single cross-sectional image produced by the imaging apparatus.

6. The system of any one of claims 1 through 5 wherein the system comprises a control apparatus that can register the instrument in a detected image space and calculate instrument movement.

7. The system of any one of claims 1 through 6 wherein the control apparatus calculates the instrument pose in the image space by generating at least three corresponding points.

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cont.

8. The system of any one of claims 1 through 7 wherein the fiducial object comprises three N-shaped fiducial motifs, and the three N-shaped fiducial motifs are non-coplanar.

9. The system of claim 8 wherein the three N-shaped fiducial motifs are arranged orthogonally in a U- shape with one fiducial motif forming the bottom and two fiducial motifs forming the sides.

10. The system of any one of claims 1 through 9 wherein the medical instrument is manipulated manually.

11. The system of any one of claims 1 through 10 wherein the system further comprises a robotic apparatus capable of positioning the apparatus.

12. The system of claim 11 wherein the instrument is positioned by the robot in the desired pose relative to the patient.

13. The system of any one of claims 1 through 12 wherein the imaging device is a CT, MRI or ultrasound device.

14. The system of any one of claims 1 through 13 wherein the fiducial object is affixed to the instrument.

15. The system of any one of claims 1 through 14 wherein the fiduciary object is integral to the instrument.

16. A method for guiding invasive therapy in a patient, comprising:
a) providing a system that comprises an imaging apparatus and a medical
instrument comprising a fiducial object that can be imaged in the same image as a
targeted site of the patient;
b) obtaining a cross-sectional image that comprises both the fiducial object
and the targeted site of the patient; and
c) manipulating the instrument with respect to the patient using information
derived from the image.

17. The method of claim 16 wherein the relative position and orientation of
the medical instrument and target site of the patient are determined from the information
contained in a single cross-sectional image.

18. The method of claim 16 or 17 wherein the instrument is manipulated using
information derived from a single reference frame of the relative position of the
instrument and target site.

Sub a/b 19. The method of any one of claims 16 through 18 wherein the instrument is
manipulated substantially contemporaneously with respect to obtaining the image.

20. The method of any one of claims 16 through 19 wherein the instrument is
manipulated based on a single image.

21. The method of any one of claims 16 through 20 wherein a plurality of
images are obtained.

22. The method of claim 21 wherein the plurality of images are taken over a
period of at least one minute.

23. The method of claim 21 or 22 wherein one or more volumetric images are
obtained.

sub a9 > *24, a9* The method of any one of claims 16 through 23 wherein a material is deposited or administered to the patient by the instrument.

25. The method of claim 24 wherein the administered or deposited material is a therapeutic agent.

sub a10 > *26, a10* The method of any one of claims 16 through 25 wherein energy is administered to the patient.

27. The method of any one of claims 16 through 22 wherein energy is removed from the patient.

28. The method of any one of claims 16 through 25 wherein tissue is removed from the patient by the instrument.

29. The method of any one of claims 16 through 28 wherein the instrument administers to the patient a radiation seed implant, a DNA therapeutic, a chemotherapeutic agent, a cryotherapeutic treatment, a sclerotic solution, ethanol, high intensity ultrasound, directed beam therapy, localized X-ray therapy, photodynamic therapy, laser ablation therapy, or RF ablation therapy.

30. The method of any one of claims 16 through 29 wherein the fiducial object representation in the image is unique for the pose of the instrument.

31. The method of any one of claims 16 through 30 wherein the image can produce three identifiable points to coordinate pose of the instrument and the targeted site of the patient.

32. The method of any one of claims 16 through 31 wherein the instrument pose is directly manipulated in reference to the medical image.

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Cont.*

33. The method of any one of claims 16 through 32 wherein the instrument is registered in detected image space by a control apparatus.

34. The method of claim 33 wherein the instrument is registered in the image space by the image generating at least three corresponding points.

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Cont.*

35. The method of any one of claims 16 through 34 wherein the fiducial object comprises three N-shaped fiducial motifs, and the three fiducial motifs are non-coplanar.

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36. The method of claim 35 wherein the three N-shaped fiducial motifs are arranged orthogonally in a U-shape with one fiducial motif forming the bottom and two fiducial motifs forming the sides.

37. The method of any one of claims 16 through 36 wherein the medical instrument is manipulated manually.

38. The method of any one of claims 16 through 36 wherein the instrument is manipulated by a robotic apparatus.

39. The method of any one of claims 16 through 38 wherein the imaging device is a CT, MRI or ultrasound device.

B4)
40. comprising:

An imaging system for invasive therapy of a patient, the system
an imaging apparatus that can provide a cross-sectional image of a patient;
a medical instrument comprising a fiducial object that can be imaged in the same
cross-sectional image as a targeted site of the patient, the image producing three
identifiable points to coordinate pose of the instrument and the targeted site of the patient;
and

a control apparatus that can register the instrument in detected image space and calculate instrument movement.

41. A method for guiding invasive therapy in a patient, comprising:

- a) providing a system that comprises i) an imaging apparatus, ii) a medical instrument comprising an associated fiducial object that can be imaged in the same cross-sectional image as a targeted site of the patient, and iii) a control apparatus that can, via input from the imaging apparatus, register the instrument in detected image space and calculate instrument movement;
- b) obtaining a cross-sectional image that comprises both the fiducial object and the targeted site of the patient, the image producing three identifiable points to coordinate pose of the instrument and the targeted site of the patient; and
- c) based on input from the control apparatus, manipulating the instrument with respect to the patient using information derived from the image.

42. A method for guiding invasive therapy in a patient, comprising:

- a) providing a system that comprises i) an imaging apparatus, ii) a medical instrument comprising an associated fiducial object that can be imaged in the same cross-sectional image as a targeted site of the patient;
- b) obtaining a cross-sectional image that comprises both the fiducial object and the targeted site of the patient, a single image providing information sufficient to coordinate pose of the instrument and the targeted site of the patient; and
- c) manipulating the instrument with respect to the patient using information derived from a single cross-sectional image.

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